CHAPTER 6

FORAGE QUALITY AROUND WATER POINTS

6.1 Introduction

Rangeland is the most important source of feed for livestock in Botswana. Livestock production from rangeland resources is variously constrained by both quantity and quality of forage produced and consumed. Identification of nutritional factors that have an influence on the animal production is, therefore, of paramount importance in the livestock industry. Prachett *et al*. (1977) indicated that the crude protein content of forages in Botswana was the single most important factor limiting animal production, whilst digestibility of the dry matter appeared to be another important nutritional factor. Weight changes in range cattle are influenced primarily by nitrogen and digestible dry matter content of the herbage selected. Phosphorus deficiency is also widespread in Botswana's rangelands and grasses rarely contain more than 0.1% phosphorus in the dry matter. A deficiency of phosphorus in cattle is responsible not only for reduced growth rates but also for poor reproductive performance (APRU 1980).

Pienaar *et al*. (1993) mentioned that it is important to be able to predict the performance of the grazing animals given a certain level of available forage of a particular quality in any livestock management program. However, they indicated that methods of feed analysis currently used do not provide data directly related to animal performance when a wide range of forages are used. Any understanding of nutritional constraints on livestock production in an area depends upon the availability of detailed knowledge of the quality of the diet available and any associated seasonal fluctuations. More efficient livestock production can only be achieved when managers are able to match nutritional requirements of their livestock with the quality of forage available. To attain this goal, more information is needed on changes in nutrient content of forages as influenced by stage of maturity and season of the year.

Based on the literature, nitrogen, phosphorus and dry matter digestibility or fibre appear to be the best indicators available to evaluate the nutrient quality of forages in Botswana's rangelands. This study was initiated as part of a multi – factor research effort to quantify the effects of grazing systems and influence of animal concentration at water points on range condition at Makhi ranch and the adjacent cattle posts in the free range grazing area. The specific objectives of this chapter were: a) to characterize the seasonal concentration dynamics of crude protein, phosphorus and fibre in the dominant forages growing around Makhi area. b) to determine the changes in nutritive quality of three forage species growing along the transect from the water point.

6.2 Material and Methods

The nutrient content of herbaceous plant species was estimated from samples obtained from both free range grazing areas and controlled conditions (ranch). In the free range grazing areas, forage samples were collected at two cattle posts. Forage samples were taken at five points along the transect from the water point. These points were located at 0, 500, 1000, 2500 and 4000 metres from the water point. These points were replicated three times on each cattle post. The zero (0m) point was located near the water trough, where animals concentrate or rest after drinking. In the free range grazing conditions, livestock kraals or abandoned old kraals exist within the vicinity of the borehole, which often make the area look more of a sacrificial area.

On the controlled grazing conditions (ranch) forage samples were collected along three transects for each grazing system. The grazing systems were replicated twice. Forage samples were taken at 0, 600, 1200, 1800 and 2400 metres from the hub. Samples were taken during clipping periods. Samples included both stems and leaves (whole plant) of grass or forbs. Samples were oven dried and ground using the Wily mill through a 1 mm screen and kept in labeled air - tight bottles until chemical analyses were done. The samples were analyzed for nitrogen (Kjeldahl method), according to Association of Official Analytical Chemists (AOAC 1996), phosphorus through ultra-violet visible spectrophotometer and crude fibre using moisture – free and ether extracted sample digested first with weak acid

solution, then a weak base solution. The organic residue was collected in a filter crucible and the loss of weight on ignition is crude fibre.

Three forage species were collected at all five points along the transect from the water point. These forage species were U. trichopus, E. lehmanniana and E. rigidior. In addition, other grass species, thought to be of importance, were collected only at one point (middle) of the paddock. These grasses included D. eriantha, S. pappophoroides, P. maximum, S. uniplumis, M. albescens, D. aegyptium, A. congesta, and A. graciliflora. Forbs included C. biensis, I. daleoides, A. thumbergii and T. terrestris.

6.2.1 Statistical Analysis

Descriptive statistics were used to summarize the data according to relevant parameters. The main effects of the season, grazing system and distance from water point on the nutritive content of the forage species were determined by General Linear Model (SAS 1990). Where differences were significant at the 5% level, Scheffe's test was used to separate the means. All differences discussed in the results or discussions are significant at the 5% level unless otherwise noted.

6.3 RESULTS

6.3.1 Seasonal nutrient content of forage species in controlled grazing conditions - Makhi ranch

The seasonal variation in crude protein, phosphorus and fibre of individual plant species in controlled grazing conditions and the surrounding free range grazing area is illustrated in Table 6.1. Nutrient concentration in forage species varied between species, season and stage of maturity. Significantly ($P<0.05$) higher levels of crude protein, phosphorus and lower fibre content occurred in summer for all plant species and the opposite trend was observed in winter. More than 7% crude protein was generally present in the herbage during the growing seasons and only 4% during the dormant season.

Table 6.1. Seasonal concentration in crude protein (%), phosphorus (ppm) and fibre (%) of plant species occurring in controlled grazing at Makhi ranch

Plant species	Seasons											
	Summer			**Autumn**			**Winter**			**Spring**		
	Protein	Phos	fibre	Protein	Phos	Fibre	Protein	Phos	Fibre	Protein	Phos	Fibre
D.eri	7.73	.063	34.11	4.39	.036	35.71	4.06	.036	35.86	4.61	.047	35.80
E.leh	6.04	.052	34.82	4.05	.040	34.73	3.83	.037	36.46	4.55	.048	36.85
E. rig	5.67	.057	32.98	4.06	.043	33.36	4.12	.044	33.02	4.02	.049	35.65
S. pap	4.98	.073	36.21	3.72	.041	38.26	3.55	.035	38.71	4.27	.044	37.30
S. uni	5.66	.061	37.02	3.98	.043	38.90	3.17	.034	38.72	4.49	.047	41.17
P. max	8.03	.081	34.00	6.80	.055	37.06	5.21	.071	34.92	5.59	.076	34.34
U. tri	9.13	.110	30.85	5.38	.048	32.46	5.42	.049	35.28	4.89	.052	35.55
M. alb	7.81	.072	25.55	3.58	.040	32.89	3.86	.043	31.49	3.32	.041	32.55
E afr	13.67	.209	30.21	6.07	.068	33.41	-	-	-	-	-	-
D. aeg	15.16	.225	29.89	9.34	.087	30.23	-	-	-	-	-	-
Aristida spp	4.67	.062	40.94	3.24	.042	40.31	3.31	.039	43.03	2.86	.022	42.36
A.thu	11.69	.289	21.70	11.2	.217	25.0	-	-	-	-	-	-
C. bei	13.71	.192	23.09	8.61	.195	29.01	-	-	-	-	-	-
I. dal	16.41	.095	23.81	6.92	.044	30.10	-	-	-	-	-	-
T. ter	13.11	.283	25.60	11.77	.213	26.70	-	-	-	-	-	-
Mean	9.27	.123	30.75	6.22	.082	33.19	4.06	.049	36.39	4.29	.053	36.84
Std Dev.	± .64	± .01	± .42	± .90	± 0	± 5.37	± .01	± .01	± 3.02	± .16	± .01	± 2.78

The highest crude protein and phosphorus and lowest fibre content occurred in all forbs and annual grass species except the Aristida species, during the growing season. Their crude protein and phosphorus content declined rapidly after summer. Table 6.1 illustrates that high nutrient levels were more pronounced for those forage species concentrated in the vicinity of the water point (A. thumbergii, T. terrestris, D. aegyptium and E. africana). Unfortunately the forage availability was limited to the growing season. The Aristida species had a very low crude protein or phosphorus content and the highest fibre content of all plant species during all seasons. Amongst the perennial grasses, the crude protein and phosphorus content of D. eriantha and P. maximum peaked at over 7% and 0.06%, respectively during summer and the fibre was as low as 34% (Table 6.1). Of the perennial grasses, S. uniplumis had the highest fibre content in all seasons. Cassia biensis and I. daleoides, representing the perennial forb component, were very high in both crude protein and phosphorus and low in fibre content but

that their foliage shattered at the end of the autumn season due to leaf senescence and finally death of the above ground stems.

Fluctuations in seasonal nutrient contant in the free range grazing area followed the same pattern shown in controlled grazing (Table 6.2). On an average basis, however,the nutrient content of the forage, especially crude protein and phosphorus, tended to be lower in the free range grazing management system compared to controlled grazing management system.

Table 6.2. Seasonal variation in crude protein (%), phosphorus (ppm) and crude fibre (%) in the free - range grazing area

Plant Species	Seasons											
	Summer			**Autumn**			**Winter**			**Spring**		
	Protein	Phos	Fibre	Protein	Phos	Fibre	Protein	Phos	Fibre	Protein	Phos	Fibre
D. eri	5.20	.051	36.63	3.59	.035	36.20	2.81	046	35.58	3.48	.037	35.42
E. leh	5.83	.053	35.82	4.21	.036	37.35	3.69	.033	36.12	3.69	.043	35.19
E. rig	5.83	.050	31.90	3.86	.053	33.77	3.37	.027	34.23	3.50	.042	35.41
S. pap	5 .45	.046	37.10	4.48	.052	35.90	3.99	.032	36.84	3.89	.041	38.85
S. uni	4.65	.040	35.55	4.41	.031	39.75	4.34	.045	40.83	3.53	.052	41.47
U. tri	6.01	.060	29.57	4.67.	.039	34.82	4.46	.039	35.20	3.64	.037	33.95
M. alb	6.03	.051	31.65	5.48	.041	33.81	4.61	.032	33.57	3.68	.032	33.67
D. aeg	12.16	.205	29.89	8.34	.089	30.23	-	-	-	-	-	-
E. afr	10.67	.197	30.21	6.07	.079	31.41	-	-	-	-	-	-
Aristida spp	4.50	.035	41.30	3.46	.028	42.24	2.70	.017	43.35	2.92	.024	42.24
C. bie	12.22	.098	26.73	10.08	.097	29.85	-	-	-	-	-	-
I. dal	14.32	.061	21.70	9.90	.062	28.20	-	-	-	-	-	-
T. ter	12.01	.222	24.09	10.56	.158	26.97	-	-	-	-	-	-
Mean	6.46	.069	32.00	5.88	.057	34.44	3.75	.034	36.91	3.54	.039	37.03
Std Dev.	± .82	± .02	± 4.34	± .7	± .01	± .42	± .17	± .01	± 2.34	± .17	± .01	± 2.52

6.3.2 Nutrient content of three forage species growing along the transect from the water

The nutrient content of the three forage species growing along the transect, from the water point at both controlled grazing conditions and the free range grazing area, is illustrated in Fig. 6.1. Significantly ($P<0.05$) high crude protein and phosphorus of the three forage species was limited to the vicinity of the water point. Urochloa trichopus contained higher levels of crude protein and phosphorus and slightly lower fibre content than either E. lehmanniana and E. rigidior at all points along the transect from the water point. Nutrient content at 500m zone and beyond was more or less constant for both the controlled grazing and the free range

grazing area. Fibre content of the three forage species was slightly lower at the first point, but the points along the transect did not differ significantly ($P<0.05$). The fibre content of E. lehmanianna was higher (36%) compared to about 34% that of U. trichopus and E. rigidior. The nutrient enrichment near the water point was reflected in the crude protein and phosphorus of the forage grown on these soils, compared to the fibre content which tended to be more or less uniform at all points throughout the transect.

The fibre content tended to be higher in forage on the free range grazing area. This might be due to the high proportion of stems to leaf in forage on free range grazing area compared to controlled grazing conditions since the whole plant sample were analyzed.

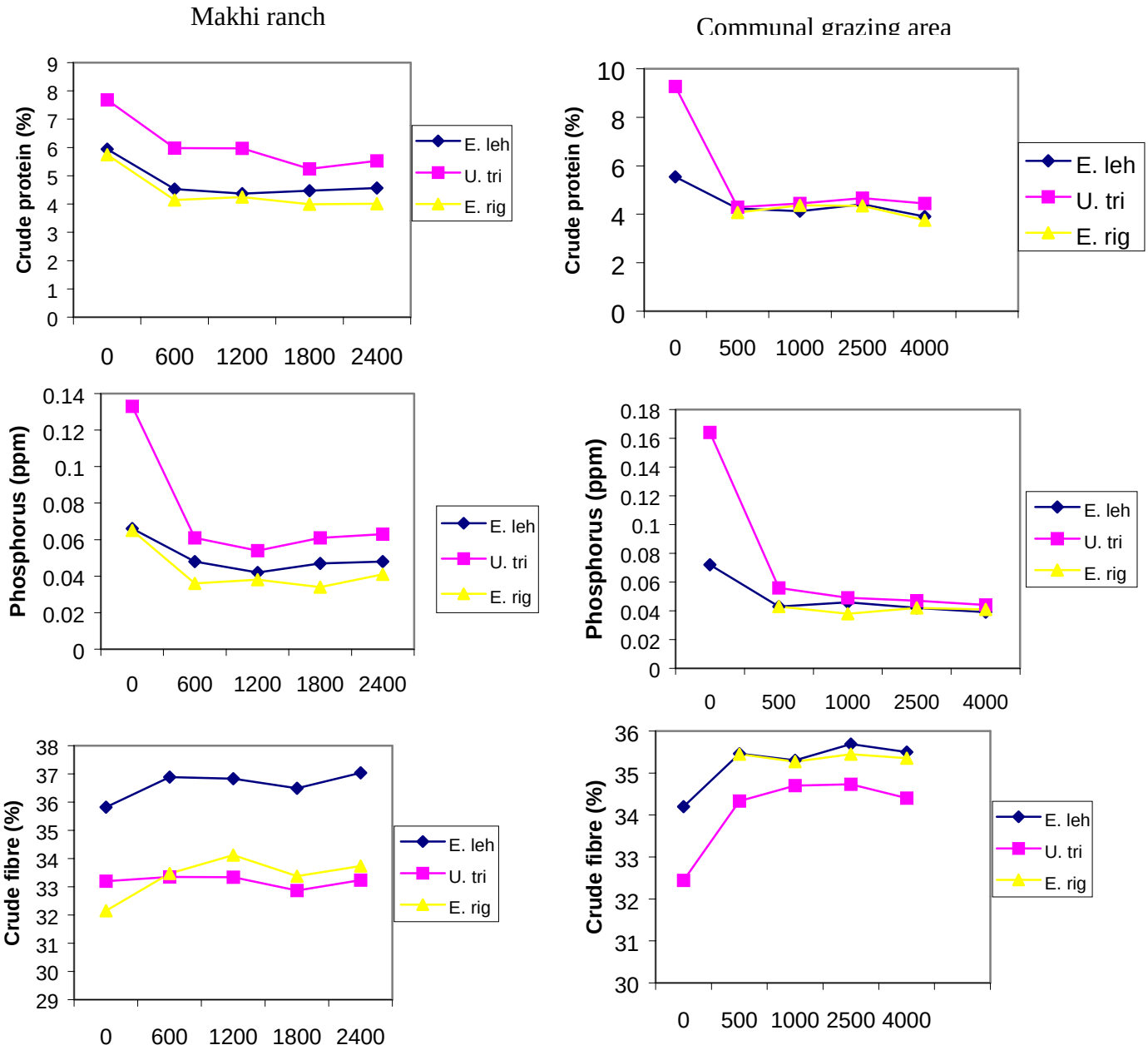

Fig. 6.1 Nutrient content of forage species growing along the transect from water point From both free range grazing and controlled conditions

Fig. 6.1 illustrates that crude protein and phosphorus contents were slightly higher in the free range grazing area than on the controlled grazing conditions at the vicinity of the water point. This might be the result of high stocking rates practiced in the free range grazing area and the

greater the impact at the water point (chapter 2).

6.3.3 Nutrient content of forage species between the grazing systems at Makhi ranch

The crude protein, phosphorus and crude fibre were not significantly (P>0.05) influenced by the grazing system when considered on average over two years (Table 3). Fourie et al. (1986) and Rosiere (1975) found no significant difference in crude protein content of forage on continuous and rotational grazing. Seasonal trends were similar for the two systems. However, studies by (Heithold *et al*. 1980) showed that continuous systems had considerably more in crude protein than rotational systems, especially in spring.

Table 6.3. Concentration of crude protein (%), phosphorus (ppm) and crude fibre % between the grazing systems

Plant species	Crude protein			Phosphorus			Crude fibre		
	1 – P	3 - P	9 – P	1 - P	3 - P	9 – P	1 - P	3 – P	9 - P
D.eriantha	4.73	5.66	5.20	.047	.048	.042	34.85	36.42	37.09
E. lehmanniana	4.43	4.66	4.76	.044	.046	.043	36.93	36.26	36.96
E. rigidior	4.18	4.54	4.48	.047	.039	.042	34.77	34.10	33.25
S. pappophoroides	4.77	4.04	4.32	.055	.049	.041	37.55	37.15	38.15
S. uniplumis	4.17	4.51	4.76	.048	.043	.048	39.53	38.70	38.63
P. maximum	6.12	6.49	6.62	.064	.059	.090	36.44	36.11	37.31
U. trichopus	6.21	6.78	6.24	.057	.062	.053	32.78	33.39	34.02
M. albescens	4.80	5.27	4.86	.040	.048	.050	30.86	30.77	30.23
D.aegyptium	12.90	10.79	10.04	.177	.178	.148	28.43	31.33	30.42
Aristida spp	3.55	3.70	3.31	.046	.041	.037	40.72	40.20	41.06
C. biensis	10.82	16.74	10.57	.089	.083	.122	29.90	29.98	30.40
I. daleoides	9.62	9.79	9.58	.072	.059	.082	24.60	24.74	24.51
T. terrestris	13.29	11.58	12.47	.281	.250	.280	24.45	24.25	26.70
Mean	4.59	6.42	5.31	.069	.051	.055	34.36	35.20	35.55
S.Dev	± 1.06	± 2.74	± 2.95	± .022	± .019	± .027	± 3.68	± 1.38	± 3.86

6.4 DISCUSSION

The development of borehole technology imposed a new environmental gradient on the savanna ecosystems with a directional nutrient transport towards the water point by deposition of dung and urine through grazing livestock (chapter 2). The change in distribution of soil nutrients is of significance for plant growth. This nutrient enrichment was reflected in the nutrient content of those herbaceous plants growing in the vicinity of the water point. In both management systems, higher nutrient levels were significantly concentrated at the location in the vicinity of the water point. The tendency for the slightly lower fibre on forage next to the water point might also be due to the heavily grazed plants with fewer stems and/ or absence of old plant material.

Seasonal differences in nutritional status of forage species have been reported widely in literature (eg. Prachett *et al*. 1977; Fourie *et al* 1986; Tolsma et al. 1987b & O'Reagan & Mentis 1990). Such differences have been shown to have a more significant influence on the quality of ingested forage than range condition (O'Reagan & Mentis 1990). There was a gradual improvement in quality as plant accumulated nutrients during the growing season, followed by a decline to the lowest level during plant dormancy. This decline was steep for nitrogen, more gradual for phosphorus or fibre. Despite the lower phytomass provided by forbs and annual grasses (U. trichopus and M. albescens), they supplied a high quality diet to livestock during the growing season.

These data illustrate that the amount of nutrients available for livestock that feed on forage varies considerably during the year. The decline in nutrients is accounted for by decline in concentration of nutrients and loss of herbage weight (chapter 4). According to Louw (1969), a crude protein content of 7 to 9% in the forage appears to be sufficient to sustain beef cattle production. These results suggest crude protein and phosphorus may limit to livestock since both were below their respective animal maintenance requirements (4% and 0.2%, respectively) during winter and /or spring. A decline in crude protein with advanced maturity and reduced availability of forage (Chapter 4) is in agreement with many other grazing studies. Despite not being statistically significant for the autumn, winter and spring seasons, the general decrease in forage quality is of biological significance to the animal. The shortage of phosphorus was not related to season. It was below the 0.2% requirement for maintenance and growth (APRU 1980; Bransby 1981& Church 1986) through out the year. Supplementary feeding is indicated as a possible method of overcoming the problems of crude protein and phosphorus during dry periods.

It should, however, be born in mind that nutrient quality determined from clipped samples had been shown to be not an accurate reflection of what the animals select from the range (Prachett et al. 1977; Shackleton & Mentis 1992). Clipped samples provide only an estimate of the sward quality because plant parts of different quality are pooled together. As such, they are lower in crude protein and higher in fibre content compared to fistula samples (Van Dyne & Heady 1965; Prachett et al. 1977; Fourie et al. 1986; Kreuter & Tainton 1989). However, clipped samples may be adjusted towards more meaningful results since a relatively constant relationship exist between crude protein of clipped and fistula samples from the same area (Shackleton & Mentis 1992).

6.5 CONCLUSION

Range plants exhibit seasonal variations in quality. An understanding of the variation in quality should aid in forage management by indicating peak periods in quality for grazing management. Knowledge of changes in forage quality under grazing is essential in designing efficient grazing management and supplementary programmes. Crude protein and phosphorus during the dry periods were believed to be the major limiting nutrients in the maintaining nutritional quality in grazing animals. Mature forage is generally only adequate to meet maintenance requirements of animals and may require supplementation of crude protein and phosphorus. The nutritional requirements of animals may also be met by conserved forages such as hay and rested / stockpile paddocks may be developed to provide for deficit periods. An other approach is the encouragement of those grass species having above average levels of crude protein, by using certain grazing systems or other rangeland manipulations. Crude protein, phosphorus and fibre were not, however, significantly influenced by the grazing systems. The nutrient enrichment of soil and forage through cattle in the vicinity of the water point was reflected in the nutrient content of forage. This zone was however, very narrow and beyond 500m, plants are not influenced by such enrichment.